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Technical Report ARMET-TR-08005

PROBING AND CAVITY FORMING EQUIPMENT INVESTIGATION FOR USE IN MELT POUR EXPLOSIVE LOADING PROCESS

PROVE-OUT STUDY USING CONTROLLED COOLING EQUIPMENT FOR ARTILLER PROJECTILES

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May 2008

U.S. ARMY ARMAMENT RESEARCH, DEVELOPMENT AND ENGINEERING CENTER

Munitions Engineering Technology Center

Picatinny Arsenal, New Jersey

REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 0704-01-0188*

1. REPORT DATE (DD-MM-YYYY)	2. REPORT TYPE	3. DATES COVERED (*From - To*)
May 2008		June 2006 to February 2008

4. TITLE AND SUBTITLE	
PROBING AND CAVITY FORMING EQUIPMENT INVESTIGATION FOR USE IN MELT POUR EXPLOSIVE LOADING PROCESS Prove-out Study Using Controlled Cooling Equipment for Artillery Projectiles	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHORS Daniel Spicer	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
U.S. Army ARDEC, METC Energetics, Warheads & Manufacturing Technology Directorate (AMSRD-AAR-MEE-P) Picatinny Arsenal, NJ 07806-5000	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) ARDEC, EM Technical Research Center (AMSRD-AAR-EMK) Picatinny Arsenal, NJ 07806-5000	10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S) Technical Report ARMET-TR-08005

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
Prototype melt pour explosive loading equipment was procured and installed in support of load, assemble, and pack modernization program at various Army Ammunition Plants around the United States. This equipment uses a new and different approach to control the cooling process of melt poured munitions that is currently not used by facilities within the United States industrial base. The equipment purchased consists of a probing unit to control the cooling of molten explosive filled projectiles, an air heater and blower to control the temperature of projectile bodies during the cooling process, a cavity forming unit that inserts aluminum liners, and other support equipment such as heat exchangers, filter, pumps, and valves. The purpose of obtaining this equipment was to prove out the technology and, if successful, possibly transfer the technology to the industrial base as required.

This report discusses the loading studies of two different 155-mm artillery projectiles, the M795 and M107, using the prototype equipment. The equipment was proven-out by loading the M795 with TNT and M107 with Comp B. This report discusses the loading studies, optimized operating parameters, advantages and disadvantages of the equipment, and recommendations based upon the lessons learned from this study.

15. SUBJECT TERMS
Naschem, Bowas, Probing, Cavity forming, Controlled cooling, Melt pour study, Controlled conditioning, Prototype, Load study, Liner, Explosive loading

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBE PERSON Daniel Spicer
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER (Include area code)
U	U	U	SAR	25	(973) 724-5706

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

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EXECUTIVE SUMMARY

The load studies performed as part of this effort were successful in proving that the prototype controlled cooling equipment that was installed in building 810 at the U.S. Army Armament Research, Development and Engineering Center (ARDEC), Picatinny Arsenal, New Jersey by Naschem is capable of producing high-quality, defect free 155-mm projectiles. The final load studies for both the M107 and M795 produced acceptable projectiles from a quality standpoint, but some minor defects were still present. The process was not further optimized due to the limited number of trials that could be performed. However, the fact that the majority of the projectiles produced from the final trials of the load study were acceptable illustrates the capability of the equipment.

Three separate trials were conducted to produce 100% acceptable M795 155-mm projectiles loaded with TNT. The first and second trials both produced 100% rejects. The process was then further optimized and the third trial produced 100% acceptable explosive casts. A single trial was required to produce seven out of eight acceptable M107 155-mm projectiles loaded with Comp B. Additional evaluation was not performed due to funding constraints.

Based on the trials that were performed, relationships were established between the operating variables of the prototype equipment and casting defects. These relationships include:

- Base gap and initial probe depth
- Piping and room temperature
- Piping and probe retraction rate
- Piping and cup temperature

The cycle time of the prototype equipment is longer than that of the cooling methods that use water carts or heating ovens, but the cycle time may be reduced with further development efforts and optimization. The conditioning times for the prototype equipment for the M107 and the M795 were both 13 hrs and then the projectiles were left in a heating cabinet overnight. The traditional water cart cooling method requires 6.5 hrs of cooling and 4 hrs of post-conditioning (typically left overnight at production sites) for the M795. The cooling oven method requires 6.5 hrs in the cooling oven and 9 hrs of post-conditioning (typically left overnight at production sites) for the M795 and 6 hrs in the cooling oven and 9.5 hrs of post-conditioning (typically left overnight at production sites) for the M107. Due to the fact that projectiles in all three cases are left in heated rooms overnight, the overall cycle times are considered comparable.

The following report provides more details related to the background, details, and findings of the load studies performed using the probing equipment.

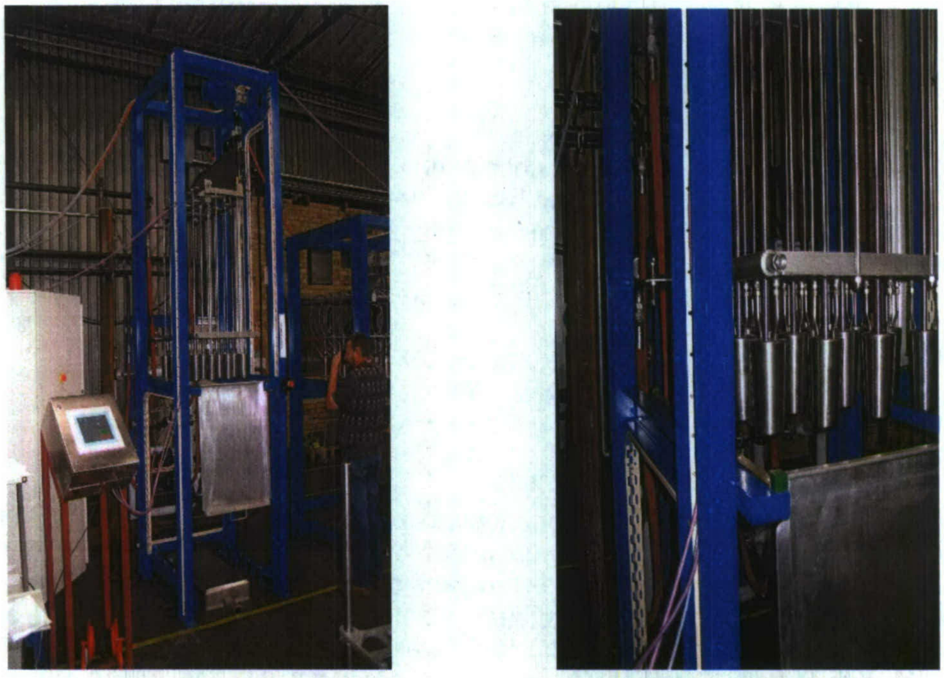
BACKGROUND

In 2004, Congress delegated funding to the Department of the Army through the Program Manager for Joint Services (PM-JS) for the purpose of modernizing the aging facilities at Army Ammunition Plants (AAP) that load high explosive (HE) melt pour projectiles. This funding covered many modernization programs at the AAP facilities, from design of new facilities and equipment to various infrastructure upgrades and efficiency studies. In support of these efforts, ARDEC was tasked by PM-JS to support these efforts by investigating new technologies from around the world that would make newer technologies available to these facilities.

In April 2005, a team of ARDEC and PM-JS representatives traveled to Europe to evaluate state-of-the-art melt pour loading equipment that was manufactured by a South African company called Naschem. It was deemed that there were opportunities to improve cooling methods and finishing methods using various components of the Naschem system. In 2005, equipment was purchased from Naschem through Bohlen Industries and Bowas Induplan of Switzerland in order to prototype new technologies at the melt pour pilot facility at ARDEC.

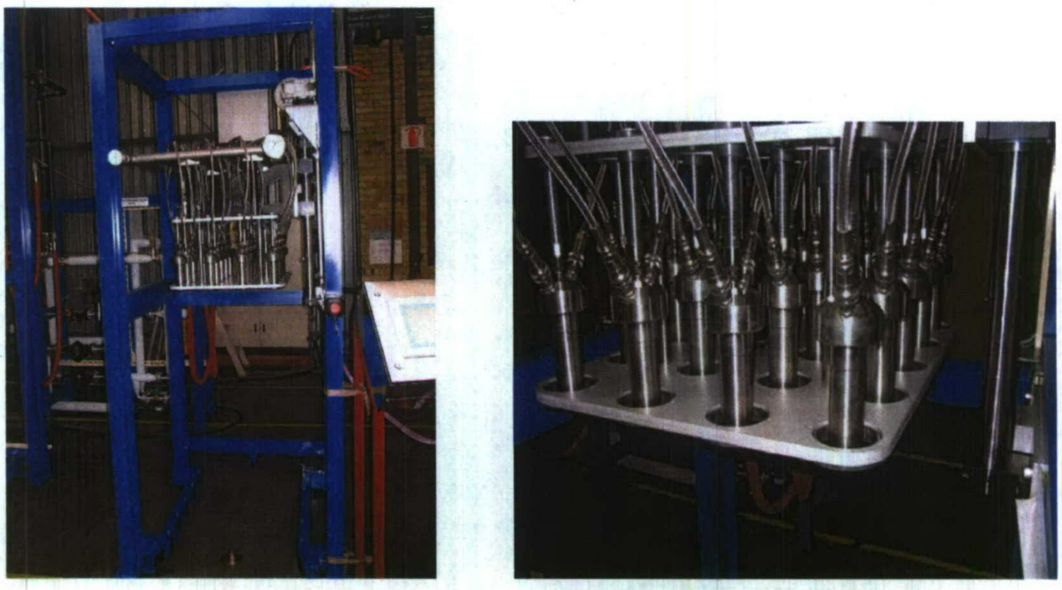
The equipment purchased was a plant room (fig. 1), which supplies hot and cold water to a probing unit (fig. 2), and a fuze well cavity-forming machine (fig. 3). The probing unit is used to control the solidification front of the molten explosive, forcing it to cool from the bottom of the projectile to the top, using a heated probe. The heated cup is placed inside the pouring funnel during the cooling process to keep the explosive in the funnel and neck of the projectile molten, while the explosive in the lower parts of the projectile solidifies. The probe is slowly retracted from the projectile over a period of time providing excellent control over the solidification front. The second piece of equipment purchased was a cavity forming/liner insertion unit. This unit eliminates the need to face and drill projectiles in order to insert the fuze well liner. Instead, this unit uses a sealant/glue substance, bitumen, which seals the explosive and holds the liner in place rather than threading and crimping. This process increases safety and reduces cycle time. In addition, loading carts, loading funnels, liners, bitumen pellets, and spare parts were included with this purchase (app A).

Figure 1
Plant module



The cart is placed in the unit and the operation takes place automatically, the pan in front is a drip tray to catch molten explosives after the operation is over. The controls and cart allow for the same unit to be used for 60-mm mortars up to 155-mm projectiles.

Figure 2
Probe unit and close up of probes and cups



The cart is placed into the unit and the operation takes place automatically. The cycle takes roughly 10 min. Each cavity head can be changed out in less than 30 sec if a different sized projectile would be used.

Figure 3
Cavity forming liner/insertion unit and close up of forming heads

The purchased equipment is capable of processing projectiles from 60-mm mortar to 155-mm artillery projectiles without defects (tooling was only purchased for two different 155-mm projectiles).

The prototype equipment was tested using the tooling and equipment supplied for the 155-mm projectiles. These projectiles were chosen due to the fact that traditionally these projectiles are the most difficult to produce with defect free casts. The cooling process and equipment are used to obtain defect free casts and the probing equipment was evaluated as an alternate method to perform controlled cooling. ARDEC engineers and technicians performed these loading studies and the following summarizes the results.

RESULTS AND CONCLUSIONS

General Information

The existing explosive melting and pouring equipment in building 810 was used in conjunction with the new prototype cooling equipment for both the M795 TNT and M107 Comp B test pours. The difference between this load study and other loading studies was to evaluate the ability of the prototype equipment to produce quality, defect-free projectiles verses the ability of the existing cooling ovens that are used. The same standard operating procedure was followed for these melt studies that are used for melt studies using the existing cooling ovens in relation to the melting and pouring processes. Also, operating parameters for the related processes, such as the melt kettle and pour machine, remained the same so that the only variable was the cooling method.

The Naschem probing equipment is used in a temperature controlled room that is heated by convection. In contrast to the existing process that controls the projectile temperature via a hot water bath. The explosive in the filling funnel of the probing equipment is kept molten by inserting a heated cup into the funnel, while typical controlled cooling systems used by the industrial base use water or steam heated panels to heat filling funnels while inside of existing cooling ovens. The last major difference between the two processes is that the prototype equipment uses a heated probe inserted into the projectile, which is then slowly retracted during the cooling cycle; typical controlled cooling ovens used by the industrial base cool the projectiles and explosive using the hot water bath or air.

The variables that can be controlled during the probing process are:

- Room temperature
- Probe temperature
- Cup temperature
- Probe depth
- Probe retraction rate during third process step

Naschem provided a general recipe outline for the process parameters to be used based on previous experience. The general recipe is a four-step process. The first step is to insert the probe and cup to a specified depth in the projectile for a specified period of time and then fully retract the probe (the cup remains in the filling funnel during the entire four-step process). The dwell period for the first step is typically 20 min long. The second step is to immediately re-insert the probe into the projectile at a slightly shallower depth for a second dwell period, which is typically 40 min, and then fully retract the probe. The third step immediately re-inserts the probe into the projectile for a specified period of time. However, once this step is complete, the probe is retracted in increments over a constant time (i.e., -10 mm every 10 min) until the probe exits the projectile. The fourth and final step of the probing process re-inserts the probe into the projectile slightly past the nose to keep the explosive in the neck of the projectile and filling funnel in a molten state for an extended period of time. The recipe format for this process can be seen in appendix A.

M795 Projectiles Loaded with TNT

The M795 projectile was the first projectile to be cooled using the new prototype equipment. Operating parameters were chosen based on previous loading experience, the recipe provided by the equipment manufacturer, and the physical characteristics of TNT. The probe and cup temperatures were set just above the melting point of TNT, 179°F and 181°F, respectively. The probe depth and time increments for the first two steps, as well as the room temperature, were chosen based on recommendations from discussions with the equipment supplier; the probe retraction rate was based on previous "bottom-up" cooling studies performed at ARDEC's prototype facility. A summary of the initial operating parameters is located in table 1.

Table 1
Operating parameters for the probing equipment for trial 1 - M795's filled with TNT

Variable	Set point
Room temperature	140°F
Probe temperature	179°F
Cup temperature	181°F
Initial Probe depth	500 mm
Probe retraction rate (step 3)	25 mm/20 minu

The initial probe depth was set to 500 mm. This is approximately 70% of the projectile depth. The time required for the first step was 20 min. The second step specified that the probe be retracted 25 mm and remain in place for 40 min. The entire cycle required 7.6 hrs. At the completion of the probing cycle, the loading cart remained in the heated room overnight and was then removed. The funnels were removed and the projectiles were then sent to x-ray.

The four M795 projectiles were poured and then sent for x-ray analysis; all four were rejected due to base gaps, heavy porosity, excessive piping, and missing explosive in the "D" section of the projectile (full x-ray results are located in appendix B). The porosity could be partially blamed on a highly viscous explosive mixture during the melting process (problems were experienced with the feather feeder during the melt), but the base gap and piping were direct results of the probing process. The "missing explosive" is explained later in the report.

Three of the four projectiles had base gaps of 0.010 in. and the fourth had a base gap of 0.020 in.; the maximum allowable base gap for the M795 is 0.005 in. These defects needed to be corrected as base gaps are critical defects and 0.00 in. is desired. Based on previous experience, the base gaps were thought to be related to room temperature or the initial probe depth and the piping was thought to be related to the probe retraction rate.

The same melting and pouring parameters were used for trial 2. The probing parameters that were used are summarized in table 2.

Table 2
Operating parameters for the probing equipment for trial 2 - M795's filled with TNT

Variable	Set point
Room temperature	120°F
Probe temperature	179°F
Cup temperature	181°F
Initial Probe depth	550 mm
Probe retraction rate (step 3)	25 mm/20 min

The initial probe depth and second step probe depth were changed to 550 mm and 525 mm, this was deeper than the values suggested by the equipment supplier due to the fact that the initial set point (70% of projectile depth) was based on the M107; the M795 has a bigger L/D ratio. The dwell times remained the same at 20 and 40 min. The entire cycle time increased to 8.3 hrs. At the completion of the probing cycle, the loading cart remained in the heated room overnight and was then removed. Once the funnel was removed, operators could see piping that was even more excessive than the first trial. The projectiles were sent to x-ray to inspect for base gaps even though it was obvious they would be rejected for piping.

As expected, all four projectiles were rejected for piping and slight porosity remained throughout the length of the projectile bodies. However, the base gap defects were almost eliminated; one projectile had a 0.010 in. base gap; the remaining projectiles had no base gaps. The piping was related to the room temperature being too cool. Through visual inspection it could be seen that the cast cooled too quickly in the area around the probe causing large pipes in the cast; the porosity was most likely caused by this as well. The next trial was conducted based on the assumption that the base gap was reduced by the increased initial probe depth and the room temperature did not have an effect. It was also inferred that due to the large piping cavities, that the cup temperature should be increased so that there would be an increase in flow of molten explosive to the cast as the projectile cooled and that the probe retraction rate should be slowed to reduce porosity.

The same melting and pouring parameters were used for trial 3. The probing parameters that were used are summarized in table 3.

Table 3
Operating parameters for the probing equipment for trial 3 - M795's filled with TNT

Variable	Set point
Room temperature	131°F
Probe temperature	179°F
Cup temperature	208°F
Initial Probe depth	550 mm
Probe retraction rate (step 3)	15 mm/20 min

The initial and second step probe depths and time increments remained unchanged at 550 mm and 525 mm and 20 and 40 min. The entire cycle was increased to 13 hrs. At the completion of the probing cycle, the loading cart remained in the heated room overnight and was then removed. When the filling funnels were removed no visible defects were present.

Four M795 projectiles were poured during trial 3 and all four projectiles were found to be acceptable after x-ray analysis. No base gaps of any size were present and no piping was found. Mild porosity was reported in the "B" and "C" zones of the projectile, but it was not excessive to the point that the projectiles were deemed rejects. The acceptable projectiles were then nose-dropped and tested to ensure tight casts. Three of the four projectiles showed no movement in the cast while the fourth showed 0.1 in. of movement. This type of movement is not acceptable, but further investigation was not conducted. No further evaluation was conducted related to the M795 projectile loaded with TNT.

M107 Projectiles Loaded with Comp B

The M107 projectile is somewhat less difficult to load as compared to the M795 projectile. This is due to two factors: (1) the L/D ratio of the M107 is much lower than that of the M795, and (2) Comp B has a lower shrinkage rate that makes it less prone to casting defects.

The probing recipe used for cooling the M107 projectile with Comp B can be found in table 4.

Table 4
Operating parameters for the probing equipment for trial 1 - M107's filled with Comp B

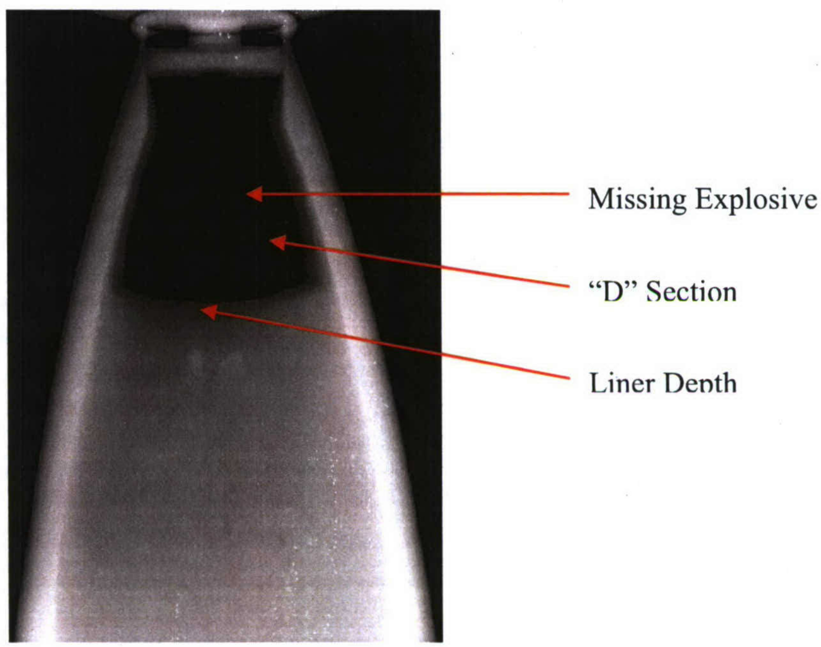
Variable	Set point
Room temperature	140°F
Probe temperature	190°F
Cup temperature	192°F
Initial Probe depth	380 mm
Probe retraction rate (step 3)	10 mm/20 min

The initial and second step probe depths were 380 mm and 360 mm, respectively, for 20 and 40 min. The cycle time for the probing process was 13.6 hrs. At the completion of the probing cycle the loading cart remained in the heated room overnight and was then removed. When the filling funnels were removed no visible defects were present.

Eight M107's were loaded and inspected by x-ray and seven were acceptable. The one projectile that was rejected had excessive piping. Two other projectiles had base gaps that measured 0.015 in., which is right at the acceptable limit for the M107 and one projectile had slight porosity, but none of these defects caused the projectiles to be rejected. The cause of the excessive piping was not determined because the projectile could not be traced to an individual probe. Further evaluation was not conducted, because it was determined that the probing equipment is capable of producing high-quality, defect-free projectiles, although some minor adjustments in the operating parameters would be necessary.

Missing Explosive in "D" Section

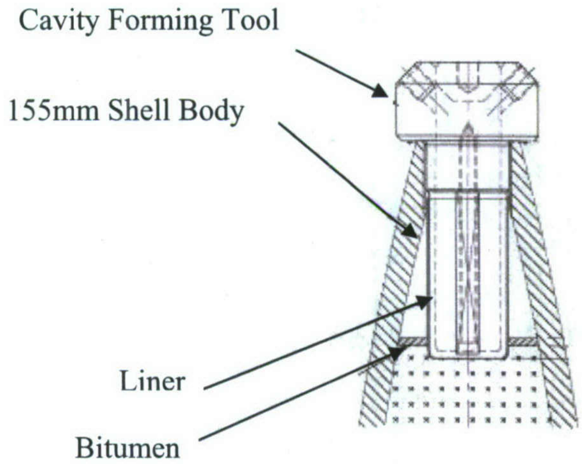
The probing equipment process is designed in conjunction with another process, the cavity forming equipment (explained in Background section). The probing equipment requires that special filling funnels are used for the loading and cooling process. The filling funnels are threaded and made of reinforced nylon. There is an o-ring present on the funnel at the interface of the funnel and the projectile. The o-ring creates an air-tight seal so that once the explosive reaches the bottom of the filling funnel it can't travel into the "D" section of the projectile-only up to the bottom of the funnel (fig. 4).



Projectiles loaded with standard filling funnels contain explosives all the way to the bottom of the nose threads. The existing liner insertion process requires the projectile to be drilled to the fuze-well liner depth. Using the Naschem funnels eliminates the drilling, facing, and crimping step of the process.

Figure 4
M107 projectile missing explosives in the "D" section

The reason for this is that when the funnel is removed the explosive breaks right at the point in the projectile where the fuze liner will be placed. As explained earlier, this eliminates the need to drill and face the explosive and also eliminates the need to swedge and crimp the liner into place. The cavity forming equipment melts the bitumen and presses the liner to the correct fuze-well depth. The next step in the process cools the liner so that the bitumen solidifies and locks the liner into place and at the same time the bitumen also seals off the explosive cast (fig. 5).



*Note the missing explosive in "D" section of projectile.

Figure 5
Illustration of cavity forming tool with inserted liner and bitumen material after melting and solidification

This process improves safety by eliminating the machining of explosive and explosive dust and combines the fuze-well drilling, facing, and liner insertion into one process that is fully automated and capable of performing these tasks on 10 projectiles simultaneously. The entire process requires approximately 10 min for one load cart.

Conclusions

The load studies that were performed showed a relationship exists between:

- Base gap and initial probe depth
- Piping and room temperature
- Piping and retraction rate
- Piping and cup temperature

Additional trials need to be performed to further eliminate porosity as porosity was never completely eliminated.

The probing cycle time is much greater than the cycle time required by cooling ovens and hot water baths, which are both used currently by production facilities, but the post conditioning time required at the production facilities makes the overall conditioning time comparable. When using the probing equipment, the loading carts are left in the probing bay, which remains heated overnight. When using hot water bath or cooling ovens, the projectiles are probed and then transferred to conditioning bays where they remain for anywhere from 2 to 9 hrs, depending on the facility. Because most production sites do not work two shifts, the projectiles are not removed from the conditioning bays until the next morning. When comparing the total cooling time and post-conditioning times, the process times are comparable. However, with further testing, it is deemed possible that the cycle time can be reduced.

The probing equipment is capable of producing high-quality, defect-free 155-mm projectiles loaded with TNT and Comp B. The equipment is a viable option for consideration related to conditioning of medium and large caliber projectiles. The equipment was designed to be flexible so that, in addition to the projectiles that were loaded, 60/81/120-mm mortars and 105-mm are also capable of being loaded.

FOLLOW-UP/PATH FORWARD

Due to the limited number of acceptable projectiles that were loaded it is recommended that follow-up studies be performed in order to optimize the process and reduce the cycle time. Future load studies could reduce the cycle time, optimize probing parameters to produce 100% defect free projectiles (including nose-drop testing), evaluate use with insensitive munitions formulations, and evaluate for use with other mortar or artillery projectiles. In addition, the cavity forming equipment should be evaluated as a possible replacement process for fuze-well drilling, explosive facing, and liner crimping.

The Explosives Pilot Processes Branch under the Energetics Producibility & Manufacturing Technology Division at the U.S. Army Armament Research, Development and Engineering Center, Picatinny Arsenal, New Jersey will provide support for further investigation into the probing equipment and evaluation of the cavity forming equipment.

APPENDIX A
PROBING EQUIPMENT RECIPE

PARAMETERS FOR M795 TNT SLURRY

	Celsius	Fahrenheit		Celsius	Fahrenheit
Heating Tunnel:	75	167	Projectile Temperature:	75	167
Melting:	104	220			
Mixing:	83	181			
Filling:	81	177			
Probing:	82	179			
Cups:	83	181			
Cooling air:	60	140			

PROBING CYCLE

Input Value

	Time (minutes)	Depth (mm)	
S1	20	500	72%
S2	40	475	69%
S3	20	450	65%
	20	425	61%
	20	400	58%
	20	375	54%
	20	350	50%
	20	325	47%
	20	300	43%
	20	275	39%
	20	250	36%
	20	225	32%
	20	200	29%
	20	175	25%
	20	150	21%
	20	125	18%
	20	100	14%
	20	75	10%
	20	50	7%
	20	25	3%
	20	0	0%
S4	20	25	3%

Total Cycle Time: 7.6 hours
Step distance: 25mm

Depth SP:1	500	Time SP:1	20
Depth SP:2	475	Time SP:2	40
Depth SP:3	450	Time SP:3	20
Index SP:MM	25	Time SP:MM	20
Depth SP:4	25	Time SP:4	20

APPENDIX B
X-RAY RESULTS

Trial 1 - M795

M795			Lot:	TNT			
Date:	5-Sep-07		Inspector:	Robert Gast			
KEY:	EP=Excessive Porosity		EC=Excessive Cavitation		EI=Excessive Piping		
	HP=Heavy Porosity		MP=Moderate Porosity		SP=Slight Porosity		
	TC(X)=Transverse Cracks(Number)		LC(X)=Longitudinal Cracks(Number)				
	CV(dim)=Cavity(Dimensions)		PI(dim)=Piping(Dimensions)		AR=Annular Ring		
REFERENCE:	R1A2050/DTL9312769-1						
	Accept/	Base	Explosive Defects, Segment:				
SER. NO.	Reject	Gap	"A"	"B"	"C"	"D"	Comments
1	*REJECT*	0.01	EP	MP	SP	SP	.56x6.00 Pipe "D" to "B", Band Porosity
2	*REJECT*	0.01	EP	MP	MP	MP	.25x4.00 Pipe "D" to "B", Band Porosity
3	*REJECT*	0.01		MP	SP	SP	.50x6.00 Pipe "D" to "B"
4	*REJECT*	0.02	EP	MP	MP	MP	.38x6.00 Pipe "D" to "B", Band Porosity

Trial 2 - M795

M795			Lot:	TNT			
Date:	29-Nov-07		Inspector:	Robert Gast			
KEY:	EP=Excessive Porosity		EC=Excessive Cavitation		EI=Excessive Piping		
	HP=Heavy Porosity		MP=Moderate Porosity		SP=Slight Porosity		
	TC(X)=Transverse Cracks(Number)		LC(X)=Longitudinal Cracks(Number)				
	CV(dim)=Cavity(Dimensions)		PI(dim)=Piping(Dimensions)		AR=Annular Ring		
REFERENCE:	R1A2050/DTL9312769-1						
	Accept/	Base	Explosive Defects, Segment:				
SER. NO.	Reject	Gap	"A"	"B"	"C"	"D"	Comments
9	*REJECT*		SP	SP, PI(1.50x3.00)	SP, PI(1.50x4.00)	No Fill	
10	*REJECT*		SP	SP, PI(1.75x5.00)	SP, PI(1.75x4.00)	HP, Fuze Well	Rotating Band Porosity
11	*REJECT*	0.01	SP	SP, PI(1.50x4.00)	SP, PI(1.50x4.00)	No Fill	Heavy Rotating Band Porosity
12	*REJECT*		SP	SP, PI(1.50x4.00)	SP, PI(1.50x4.00)	No Fill	

Trial 3 - M795

M795			**Lot:**	TNT			
Date:	20-Feb-08		**Inspector:**	Robert Gast			
KEY:	EP=Excessive Porosity		EC=Excessive Cavitation		EI=Excessive Piping		
	HP=Heavy Porosity		MP=Moderate Porosity		SP=Slight Porosity		
	TC(X)=Transverse Cracks(Number)		LC(X)=Longitudinal Cracks(Number)				
	CV(dim)=Cavity(Dimensions)		PI(dim)=Piping(Dimensions)		AR=Annular Ring		
REFERENCE:	R1A2050/DTL9312769-1						
	Accept/	**Base**	**Explosive Defects, Segment:**				
SER. NO.	**Reject**	**Gap**	**"A"**	**"B"**	**"C"**	**"D"**	**Comments**
13	ACCEPT			MP	MP	Missing	
14	ACCEPT			MP	MP	Missing	
15	ACCEPT			MP	MP	Missing	
16	ACCEPT			MP	MP	Missing	

Trial 1 - M107 (projectiles 9 through 16 are related to probing study, projectile's 1 through 8 were conditioned using cooling ovens)

M107			Lot:	CompB			
Date:	20-Dec-07		Inspector:	Robert Gast			
KEY:	EP=Excessive Porosity		EC=Excessive Cavitation		EI=Excessive Piping		
	HP=Heavy Porosity		MP=Moderate Porosity		SP=Slight Porosity		
	TC(X)=Transverse Cracks(Number)		LC(X)=Longitudinal Cracks(Number)				
	CV(dim)=Cavity(Dimensions)		PI(dim)=Piping(Dimensions)		AR=Annular Ring		
REFERENCE:	MIL-P-60377B (AR)						
	Accept/	Base	Explosive Defects, Segment:				
SER. NO.	Reject	Gap	"A"	"B"	"C"	"D"	Comments
1	ACCEPT			SP	SP	MP	
2	ACCEPT			SP	SP	MP	
3	***REJECT***	.015"		SP	EP	HP	
4	***REJECT***	.015"		SP	EP	MP	
5	***REJECT***			SP	EP	EP	
6	***REJECT***			SP	EP	EP	
7	ACCEPT			SP	SP	MP	
8	***REJECT***			SP	EP	EP	
9	ACCEPT			SP	SP	MISSING	
10	ACCEPT			SP, CV(.25")	SP	MISSING	
11	ACCEPT	.015"		SP	SP	MISSING	
12	***REJECT***			SP	EP	MISSING	
13	ACCEPT			SP	SP	Fuze Well Drilled	
14	ACCEPT			SP	SP	MISSING	
15	ACCEPT	.015"		SP	SP	MISSING	
16	ACCEPT			SP	SP	MISSING	

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